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ABSTRACT

Observations during research involving the Bruce Treadmill Test (BTMT) indicating that Stage III for females and Stage IV for males represented speeds which are intermediate between comfortable walking and confortable jogging for many subjects, prompted this study to determine ways to obtain more consistent group results. Twenty-eight subjects (fourteen males and fourteen females) ages 20 to 27 performed two Bruce tests on separate days. The subjects walked throughout the stage in question in one test and jogged throughout that stage in the other test. On the average, females had longer test durations when walking than when jogging in stage III, while males had longer test durations when jogging than when walking during stage IV. Other data indicated that the ranges of individual differences in test durations between walking and jogging protocols represented differences between predicted and measured aerobic capacity of up to nineteen percent of measured capacity. The investigation demonstrated that physiological performance and prediction of aerobic capacity in some individuals were greatly affected by the choice of movement mode in Stages III and IV of the BTMT. It was recommended that those interested in predicting aerobic capacity from BTMT performance time on this age group would obtain more consistent group results by: (1) advising males to jog in Stage IV and (2) advising females to walk in Stage III. (Author/MB)

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WALKING VERSUS JOGGING IN STAGES III AND IV OF THE BRUCE TREADMILL TEST*

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INTRODUCTION

Astrand (1) has indicated that the same person using different techniques in approaching the Stage III of the Bruce Treadmill Test (BTMT) would result in the following physiological responses:

	Walking	Walking Holding Bar	Jogging	Jogging Holding Bar
$\dot{V}_{O_2}$ ML/KG/min.	38	29	42	39
Heart rate beats/min.	155	138	168	160

Bruce Treadmill Test Stage III = 14% elevation and 3.4 miles per hour

The Human Performance Laboratory at Oral Roberts University has initiated a longitudinal research project on the "Influence of Physical Activity and Fitness on CHD Risk Factors." Aerobic capacity ($\dot{V}_{O_2}$ max) is estimated from BTMT performance time. The difference in response with various approaches cited by Astrand concerned us because we do not presently influence the subject's approach to the various stages of the BTMT in terms of jogging or walking except that subjects are not permitted to hold the bar during the test. In our testing, it was observed that Stage III for females and Stage IV for males represented speeds

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which were intermediate between comfortable walking and comfortable jogging for many subjects. We test subjects in the fall and spring of freshman, sophomore, senior, and post-graduate years. Since we perform repeat tests at various intervals, we were interested in determining whether the walking vs. jogging protocols would significantly influence the performance time and physiological response on the BTMT.

METHODS

In an attempt to determine whether the mode of movement in Stage III for women and Stage IV for men affect performance time and physiological response on the BTMT, 28 subjects (14 males and 14 females) performed the BTMT to voluntary maximum on separate days one week apart and at the same time of day. The subjects mean age -- males = 21.6 ± 1.8, females = 23.3 ± 3.9) all had been active in aerobic activities on a regular basis, were apparently at a stable level of cardiorespiratory fitness and had previous experience with the treadmill test.

The subjects walked on the Quinton treadmill through the stage in question in one test and jogged through that stage in the other test, with protocols randomly assigned. Heart rate was taken from ECG strips recorded the last ten seconds of each minute throughout the test. Before the BTMT began, subjects were given instructions on protocol and encouraged to give a maximum effort. The exercise test was terminated when the subject grabbed the bar signalling he/she wanted to stop.

Oxygen uptake was assessed throughout the test by use of the Beckman Metabolic Measurements Cart (MMC) with various metabolic values printed out every 30 seconds. The electronic analyzers in the MMC were calibrated against precision gases, standardized by means of a Gallenkamp-

lloyd gas analyzer before and immediately following each test. All MMC measurements of volume, gas concentration, temperature and barometric pressure were calibrated as suggested by the manufacturer. MMC data were taken as computed and recorded by the MMC, with no corrections made for pre- to post-test drift. Performance evaluations have been conducted by Wilmore, et al. (2) and Schwane and Cundiff (3) and have demonstrated the Beckman MMC yields good metabolic data during exercise testing. The regression equations developed at ORU were used to estimate $\dot{V}_{O_2}$ max from BTMT duration (Table 1).

RESULTS

As indicated in Table 2, females had longer ($P = < .10$) test durations when walking ($\bar{X}$ = 11.20 ± .81 min.) than when jogging ($\bar{X}$ = 10.96 ± .77 min.) in Stage III, while males had longer ($P = < .01$) test durations when jogging ($\bar{X}$ = 14.01 ± 1.55 min.) than when walking ($\bar{X}$ = 13.52 ± 1.67 min.) and greater ($P = < .01$) total O_2 cost when jogging ($\bar{X}$ = 33.64 ± 6.70 ml/kg/min.) than when walking ($\bar{X}$ = 31.60 ± 7.29 ml/kg/min.) in Stage IV. No statistically significant differences existed between walking and jogging protocols in peak heart rate, $\dot{V}_E$, $\dot{V}_{O_2}$, or RQ value. However, there were many large individual differences in certain variables between the two protocols. The ranges of individual differences in test duration between walking and jogging protocols were a -0.50 to a +1.0 minutes for females and a -.34 to a +1.42 for males representing differences between predicted and measured $\dot{V}_{O_2}$ max of up to 19 percent of measured $\dot{V}_{O_2}$ max (Table 3). It should be noted that the largest variations occurred in the walking protocols. Ability to predict $\dot{V}_{O_2}$ max from BTMT duration was enhanced slightly in both males (R^2 = .89) and females (R^2 = .74) by additional knowledge of type of protocol, height, and weight.

Table 4 shows comparisons of physiological response to walking vs. jogging on the BTMT in Stage III (females) and IV (males). In Stage III the O_2 cost was greater ($P = < .01$) for females when jogging ($\bar{X} = 5.60 \pm .61$ liters) than when walking ($\bar{X} = 6.04 \pm .71$ liters) and the $\dot{V}_{O_2}$ was higher ($P = < .001$) in the last minute of Stage III when jogging ($\bar{X} = 2.24 \pm .09$ liters) than when walking ($\bar{X} = 2.11 \pm .07$ liters). In Stage IV the O_2 cost was greater ($P = < .01$) for males when jogging ($\bar{X} = 9.99 \pm 2.90$ liters) than when walking ($\bar{X} = 9.63 \pm 1.53$ liters) and the $\dot{V}_{O_2}$ was higher ($P = < .01$) in the last minute of Stage IV when jogging ($\bar{X} = 3.53 \pm .25$ liters) than when walking ($\bar{X} = 3.41 \pm .23$ liters). Although no statistically significant differences were observed in heart rate with either group between walking and jogging protocols, the trend was toward a higher heart rate for females and lower heart rate for males in the jogging protocols.

Table 5 compares the height, BTMT duration and $\dot{V}_{O_2}$ max of female subjects who had their best treadmill performance time in the jogging or walking protocol (evenly divided 7/7). Although differences did not reach statistical significance, subjects who were taller tended to have longer test duration and higher $\dot{V}_{O_2}$ max in the walking protocol ($\bar{X} = 65.9 \pm 2.29$ inches) compared to those with best performance in jogging protocol ($\bar{X} = 64.3 \pm 3.19$ inches). By comparison, only one male had a longer (20 seconds) test duration in the walking vs. the jogging protocol.

Table 6 compares the peak $\dot{V}_{O_2}$ measured vs. estimated between the walking and jogging protocols. Females had higher ($P = < .10$) estimated $\dot{V}_{O_2}$ in walking protocol ($\bar{X} = 42.4 \pm 2.77$ ml/kg/min.) and males had higher ($P = < .01$) estimated $\dot{V}_{O_2}$ in jogging protocol.

CONCLUSIONS AND RECOMMENDATIONS

This investigation demonstrated that physiological performance and prediction of $\dot{V}_{O_2}$ max in some individuals were greatly affected by the choice of movement made in Stages III and IV of the BTMT. Those interested in predicting aerobic capacity from BTMT performance time on this age group would obtain more consistent group results by:

1. Advising males to jog in Stage IV.
2. Advising females to walk in Stage III.

(1) Astrand, P. O. "Physiologic Changes During Dynamic Exercise." Presented at workshop on Exercise Testing in Children and Young Adults, sponsored by the ACC at Cincinnati, Ohio, Sept. 13, 1976.

(2) Wilmore, J. H.; Davis, J. A.; Norton, A. C. "An Automated System for Assessing Metabolic and Respiratory Function During Exercise." Journal of Applied Physiology, 40:619-624, April 1976.

(3) Schwane, J. A. and D. E. Cundiff. "Performance Evaluation of the Beckman Metabolic Measurements Cart," study conducted in 1976 and available from the Human Performance Laboratory, Oral Roberts University, Tulsa, Oklahoma 74102.

TABLE 1

Estimation of $\dot{V}_{O_2}$max In Healthy Subjects From Bruce Test Duration

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Bruce et al. (1973) --------- 138 males and females ($\bar{X}$ age = 49.0)

Est. $\dot{V}_{O_2}$max = 6.70-(2.82 x sex factor) + (0.056 x duration in sec.) R = 0.92

♂ = 1 ♀ = 2

Froelicher et al. (1975) ---- 77 males ($\bar{X}$ age = 35.9)

Est. $\dot{V}_{O_2}$max = -8.38 + (4.77 x duration in min.) r = 0.87

Pollock et al. (1976) ------- 51 males ($\bar{X}$ age = 40.5)

Est. $\dot{V}_{O_2}$max = (4.326 x duration in min.) -4.66 r = 0.88

ORU (1977) ---------- 35 males ($\bar{X}$ age = 22.5)

Est. $\dot{V}_{O_2}$max = (3.757 x duration in min.) + 1.25 r = 0.88

---------- 47 females ($\bar{X}$ age = 21.1)

Est. $\dot{V}_{O_2}$max = (3.427 x duration in min.) + 4.07 r = 0.92

TABLE 2

Comparison of Walking vs. Jogging Protocols on Bruce Test Performance

		Walking (N = 14)	Jogging (N = 14)		
		$\bar{X}$ SD	$\bar{X}$ SD	t	P
Females	Test Duration (min.)	11.20 ± .81	10.96 ± .77	1.92	<.10
	Peak HR (b/min.)	187.0 ± 7.9	187.6 ± 5.7	.44	NS
	Peak $\dot{V}_{O_2}$ (l/min.)	2.60 ± .28	2.58 ± .28	1.17	NS
	Total O_2 Cost (liters)	17.62 ± 2.54	17.18 ± 2.17	1.37	NS
Males	Test Duration (min.)	13.52 ± 1.62	14.02 ± 1.55	3.99	<.01
	Peak HR (b/min.)	194.1 ± 8.9	195.5 ± 8.8	1.19	NS
	Peak $\dot{V}_{O_2}$ (l/min.)	3.96 ± .65	3.99 ± .58	.39	NS
	Total O_2 Cost (min.)	31.60 ± 7.29	33.64 ± 6.70	3.64	<.01

TABLE 3

INDIVIDUAL DIFFERNECES BETWEEN $\dot{V}_{O_2}$MAX ESTIMATED FROM BTMT DURATION AND MEASURED $\dot{V}_{O_2}$MAX (ml/kg/MIN.)

	SUBJECT/HT.	PROTOCOL	TEST DUR. (MIN.)	ESTIMATED $\dot{V}_{O_2}$MAX	MEASURED $\dot{V}_{O_2}$MAX	% DIFF.
FEMALES	J.B. (61")	WALK	11:25	43.2	47.7	9.6
	J.H. (64½")	WALK	9:45	37.5	41.2	9.0
MALES	D.G. (71")	WALK	11:45	45.4	40.5	12.1
	H.G. (72½")	WALK	16:05	61.7	69.2	10.8
	W.W. (75")	WALK	12:55	49.8	41.7	19.4

*ORU REGRESSION EQUATION

TABLE 4

PHYSIOLOGICAL RESPONSE TO WALKING VS. JOGGING PROTOCOL ON THE BTMT

		WALKING (N = 14)		JOGGING (N = 14)			
		$\bar{X}$	SD	$\bar{X}$	SD	t	P
FEMALES	O_2 COST (LITERS)	5.60	± .61	6.04	± .71	3.13	<.01
	$\dot{V}_{O_2}$ FINAL MIN. (l/MIN.)	2.11	± .07	2.24	± .07	4.93	<.001
	HEART RATE (b/MIN.)	175.1	± 9.98	177.29	± 5.97	1.40	NS
MALES	O_2 COST (LITERS)	9.63	± 1.53	9.99	± 2.90	3.24	<.01
	$\dot{V}_{O_2}$ FINAL MIN (l/MIN.)	3.41	± .23	3.53	± .25	3.24	<.01
	HEART RATE (b/MIN.)	188.1	±11.67	186.2	±10.79	1.32	NS

TABLE 5

INFLUENCE OF HEIGHT ON BRUCE TEST DURATION* AND PEAK $\dot{V}_{O_2}$ IN FEMALES

	WALKING (N = 7)		JOGGING (N = 7)			
	$\bar{X}$	SD	$\bar{X}$	SD	t	P
HEIGHT (INCHES)	65.9	± 2.29	64.3	± 3.19	1.04	NS
DURATION (MIN.)	11.46	± .79	11.0	± .77	1.12	NS
PEAK $\dot{V}_{O_2}$ (ml/kg/MIN.)	43.1	± 2.50	42.3	± 2.85	.55	NS

*SUBJECTS WERE DIVIDED ON BASIS OF MOVEMENT MODE WHICH PRODUCED LONGEST BRUCE TEST DURATION

TABLE 6

INFLUENCE OF BTMT WALKING VS. JOGGING PROTOCOL ON MEASURED AND ESTIMATED* $\dot{V}_{O_2}$MAX (ml/kg/MIN.)

		WALKING		JOGGING			
		$\bar{X}$	SD	$\bar{X}$	SD	t	P
FEMALES	MEASURED $\dot{V}_{O_2}$MAX	43.1	± 2.79	42.6	± 2.86	1.54	NS
	ESTIMATED $\dot{V}_{O_2}$MAX	42.4	± 2.77	41.6	± 2.64	1.97	<.10
MALES	MEASURED $\dot{V}_{O_2}$MAX	53.2	± 8.72	53.5	± 7.10	.33	NS
	ESTIMATED $\dot{V}_{O_2}$MAX	52.0	± 6.28	53.9	± 5.83	4.01	<.01

*ORU REGRESSION EQUATION